The cost of building to the near Zero Energy Building standard – a financial case study

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Shane Colclough[1#], John Mernagh[2], Derek Sinnott[2], Neil J Hewitt[1], Philip Griffiths[1]

[1] Ulster University, Newtownabbey, Co Antrim, BT370QB, Northern Ireland

[2] Waterford Institute of Technology, Cork Road, Waterford, X91 K0EK, Republic of Ireland

[#]Corresponding author: Dr. Shane Colclough, S.Colclough@Ulster.ac.uk

Abstract

The EU has mandated that all buildings are built to the nearly Zero Energy Buildings (nZEB) standard from 2020. The Passivhaus standard has been in existence for over 25 years and potentially offers a tried and tested method of achieving nZEB, but can it be used as a cost-effective means of achieving nZEB?

This paper analyses the cost differential of building dwellings located in the South East of Ireland to the nZEB standard using the Passive House methodology, in comparison to building to the current prevailing minimum building regulations. A comparison of the two standards is also made to determine the suitability of using the Passive House standard as a means of achieving nZEB compliance. In the analysis, the extra cost (compared with building to the minimum building regulations) include increased airtightness, insulation levels, a heat recovery and ventilation system and higher performing windows and doors. Cost reductions are achieved in the elimination of the traditional heating system, chimney stack and reduced site overheads. Costs are based on a designated date for the works of 1 January 2017, exclude VAT at the prevailing standard and reduced rates, exclude cost of site purchase, and exclude any design team or professional fees arising.

The costs are compared on an Element by Element basis using the National Standard Building Elements and Design Cost Control Procedures (Anon, 1993) format for comparison, the accepted industry standard in the Republic of Ireland for subdividing the overall cost of construction into logical and defined cost headings and is assembled in order of the sequence of construction. The comparison shows that while differences exist in individual elements the overall cost differential between constructing a residential dwelling to current building regs and that of Passivhaus standard is just +€131 excl VAT. It is noted that while this specific analysis has been carried out on the basis of a case study, it is proposed that the analysis will be of general applicability given the similarities in the large cost items between those mandated by the building regulations, and those required in order to achieve the Passive House standard (such as insulation levels).

Keywords

nZEB, Passive House, passivhaus, financial analysis

Introduction

Given the planned 2020 implementation of the nearly-Zero Energy Building (nZEB) standard across the European Union, the well-established passive house (PH) standard is seen as a viable means of achieving the mandated high-energy efficiency standard. While a number of publications have been written to investigate the potential for the passive house standard in the Irish climate (e.g. [1, 2]) and a number have considered net zero energy buildings [3, 4] and also compared the PH with the newly defined nZEB standard for the Republic of Ireland [5], little has been written about the cost of achieving nZEB in comparison with the current building regulations for constructed dwellings. This paper takes the approach of analysing the costs in detail for a case study scheme of houses.

The nZEB standard in Ireland (to be finalised in 2019) requires that dwellings must consume less than 45 kWh/m2/a [6]. Moran [7] carried out research into the life cycle cost, energy and global warming potential analysis of nZEB in a temperate oceanic climate, and found that for a residential semi-detached nZEB, focus should be placed on minimising the space heating requirements through high thermal and air tightness performance, and covering the remaining energy demand, through renewable sources such as a biomass boiler or heat pump. Colclough et al. [5] demonstrated that a case study certified passive house dwelling complies with the nZEB standard using this approach, i.e. a passive house in combination with heat pump and solar PV. Thus the financial case study considered here is seen to be highly relevant for future dwellings in the temperate maritime climate.

While other developers have reported that building to the passive house standard is cost neutral compared with the current building regulations [8], obtaining detailed information on the construction costs of dwellings is difficult given commercial sensitivity. The developer of the case study dwelling considered here has carried out cost analyses since 2010 of building to the passive house standard compared with the prevailing building regulations, and it is seen that costs have reduced in line with the increasing energy efficiency standards of the building regulations. Mullins [9] reported that the additional cost for a single dwelling was €18,010, while this cost was seen to reduce to €4000 in the case of a scheme of dwellings in 2015 [10]. This paper provides a detailed breakdown of costs for a scheme of houses which is described below, comparing the cost of constructing the dwellings to the current minimum building regulations – i.e. achieving a building energy rating (BER) of A3, with the cost of construction to comply with the nZEB – i.e. a BER of A1. The BER is the measure of energy performance and reflects the amount of energy required for space and water heating, ventilation and lighting, based on standard occupancy.

The nZEB dwellings were designed using the passive house planning package (PHPP) and are independently certified as achieving the passive house standard. In meeting the passive house standard, the dwellings outperform the nZEB requirements with respect to air infiltration (achieving 0.6 air changes per hour rather than the mandated 7m^3/m^2/hr), and making use of a mechanical heat recovery ventilation system which is not required for nZEB compliance. The passive house might therefore be expected to be more expensive than a dwelling merely complying with the nZEB standard. However, this analysis will show that the

elimination of the traditional heating system, along with the more streamlined construction process for the passive house offset the aforementioned additional costs.

The detailed base costs presented are produced independently of the developer and are based on market costs current to 1 January 2017 subject to the caveats listed in the second paragraph of this report.. The cost differential associated with constructing to the minimum building regulations (i.e. to a BER of A3) and constructing to the passive house standard (to achieve a BER of A1) is analysed in consultation with the developer of the scheme of case study dwellings.

Description of the case study dwelling

The case study dwellings comprise 3 bedroom, 2 story semi-detached houses, each with a total floor area of 103m^2 (see fig 1 & 2). The PH dwellings are completed within a 13 weeks construction period, while an extra week is required in the case of the A3 dwelling, primarily for work associated with the wet heating system and associated chimney.

While the scheme was designed to achieve passive house certification and to meet the minimum renewable energy required by the current building regulations, analysis [5] has shown that such a dwelling is also compliant with the nZEB standard (ie i.e. less than 45 kWh/m^2/a) in addition to it achieving a Building Energy Rating (BER) of A1 i.e. less than 25 kWh/m^2/a.

For both the A1 and the A3 dwellings, the construction method is that of 10cm external rendered blockwork, 5cm cavity and insulated internal timber frame leaf. Each dwelling has 6 m² of solar PV panels in order to meet the renewables requirement of the building regulations.

However, while the dwellings have many similarities, there are a number of significant differences. For example, in the case of the Passive house, certified P.V.C triple glazed windows and doors are used and an air tight attic hatch ensures that the required air infiltration standard of less than 0.6 changes per hour is achieved at 50 Pa. The heating system used is a Nilan Compact P heat recovery ventilation system which provides both space and DHW heating via an integrated electric heat pump. In comparison for the A3 dwelling, double glazed windows, less external insulation and natural ventilation result in reduced construction costs, whereas, extra costs are incurred in the provision of the traditional wet heating system with associated chimney. Table 1 gives an overview of the parametric comparison comprising the main energy influencing elements of the dwellings.

Item		A3	A1
Thermal Envelope		{W/m²K}	{W/m²K}
Insulation U Value	Roof	0.16	0.07
	Floor	0.21	0.08
	Walls	0.21	0.17*
	Windows & Doors	1.24	0.74
Ventillation system		Natural Ventilation	Heat Recovery Ventilat
Heating System	Main	Oil Fired Central Htg	2 x 550W Electric rads 2 x 175W Towel rads
	Backup	& Multifuel Stove	& air post heater
DHW		Immersion	Heat Pump

Table 1 Parametric comparison - Energy influencing elements

Figure 1 Front, rear and side elevations of case study dwelling

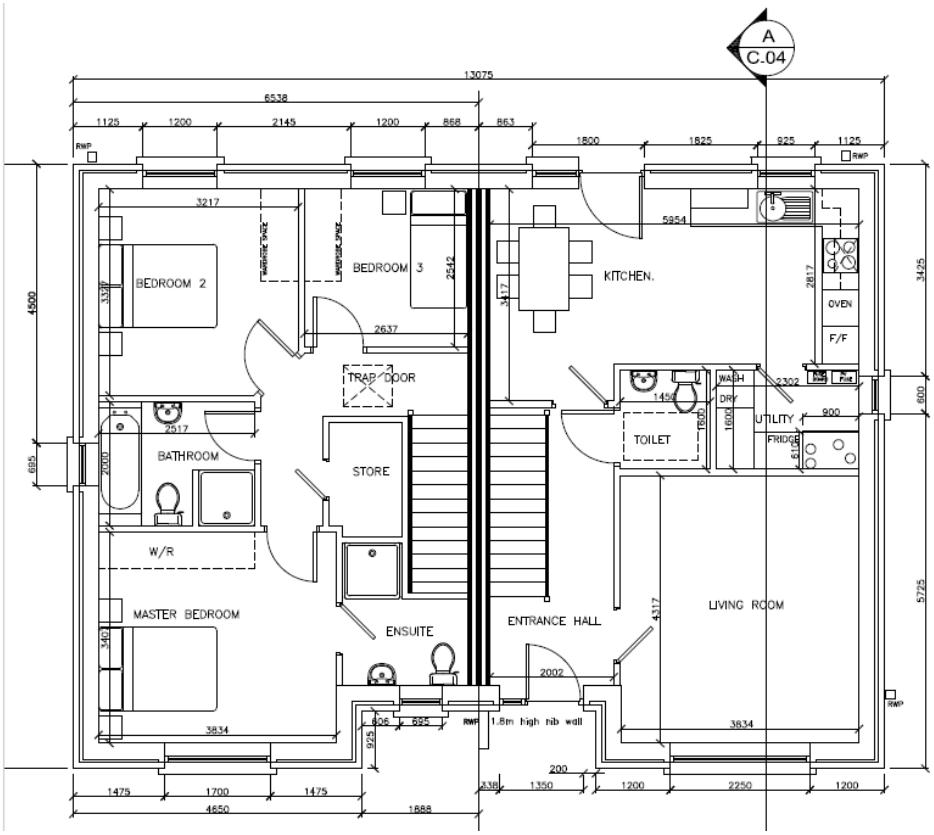

Figure 2 Plans of case study dwelling

Cost Comparison

The approach taken in this analysis is to compare the cost of constructing the house depicted in figure 1 & 2 to achieve a BER of A3 with that required to achieve an A1 rating. The analysis is based on a scheme of houses (for both nZEB and A3 costs examined), and not a single house project and therefore includes the economy of scale and buying power a developer enjoys when constructing this number of concurrent buildings of a similar design

Table 2 gives a breakdown of the estimated construction costs for both the same dwelling to comply with the current building regulations (i.e. achieve a BER of A3) and comply with the future mandated nZEB regulations (and achieve a BER of A1).

In Element (19) Substructure, 80 mm less insulation is required in the foundations of the A3 dwelling compared with the nZEB, resulting in a cost reduction of -€725, while an additional cost of +€10 excl VAT is required to reduce cold bridging associated with the chimney stack inherent in the design of the A3 dwelling, leading to an overall net reduction in cost of -€715 excl VAT for the A3 dwelling in this Element.

Examining Element (21) External Walls in a similar fashion, the current building regulations require a less costly wall build up and level of insulation to the cavity wall (saving -€1,786) and also attracts less cost for the detailing required to eliminate cold bridging in the building envelope (resulting in further savings of -€1,384), which combined lead to an overall cost reduction of -€3,170 excl VAT in this Element compared with the nZEB standard.

Schedule of Areas (M²)	M²		M²
Total Gross Floor Area (GFA M²)	**102**		**102**
Elemental Breakdown of Estimated Costs	**€**		**€**
Current Regs	**nZEB**		**Current (A3)**
(19) Substructure	6,923		6,208
(21) External Walls	12,108		8,938
(22) Internal Walls	7,462		7,462
(23) Suspended Floors	4,233		4,233
(24) Stairs/Ramps	1,894		1,894
(27) Roof	8,114		8,114
(28) Frames	-		-
(31) External Wall Completions	11,850		10,950
(32) Internal Wall Completions	7,989		7,989
(33) Suspended Floor Completions	-		-
(34) Stair Completions	621		621
(37) Roof Completions	-		-
(41) External Wall Finishes	4,554		4,554
(42) Internal Wall Finishes	4,905		4,905
(43) Floor Finishes	1,946		1,946
(44) Stair Finishes	-		-
(45) Ceiling Finishes	5,444		5,444
(47) Roof Finishes	6,665		6,665
(52) Drainage/wastes	704		704
(59) Mechanical Services (inc associated builders works)	9,838		12,488
(66) Transport services	-		-
(69) Electrical Installation (inc associated builders works)	7,890		7,890
(74) Sanitary Fittings	2,266		2,266
(79) Building Fittings	3,156		3,156
(-) External Works	2,500		2,501
Sub Total 1	**111,062**		**108,928**
Preliminaries	3,800		6,065
Sub Total 2 EX VAT	**114,862**		**114,993**

Table 2 Cost Comparison 2015 & nZEB Building Regulations

External Wall completions Element (31) compares the cost of the external windows and doors and shows a cost saving of -€900 excl VAT when constructing the current building regulations dwelling compared with the PH dwelling, as double glazed windows, (at a cost of €3,300) are less costly than the, triple glazed nZEB windows (at a cost of €4,200).

Element (59) Mechanical Installation (Plumbing and Heating) shows that there is an additional cost of +€2,650 excl VAT associated with constructing to the current A3 regulations over the nZEB dwelling (via the passive house route). All associated and ancillary cost associated with the Plumbing and Heating of each unit in this Element are included. Cost savings are achieved in the A3 unit by not having to provide a HRV system to

meet the low space heating demand of 10 W/m2 of the Passivhaus standard (thus saving -€8,748). Similarly the two 550 watt heaters to the upstairs bedrooms (saving -€1,090) can be omitted. However additional cost will be incurred for the A3 dwelling when compared with the PH standard in the following areas:1) a chimney stack and associated plasterwork and capping will be required at +€2,931; 2) mechanical ventilation will be required to the A3 unit with 5 fans included in this design at a cost of +€922; 3) the A3 unit will require a traditional heating system with associated radiators, oil burner and cylinder at a cost of +€6,125; 4) an Electrician will be required to wire the foregoing at +€350; 5) a Carbon Monoxide alarm will be needed in the A3 unit at a cost of +€85; 6) the builders work associated with the foregoing, i.e. trenches, boxouts, oil line, cradle, opes and plinth will carry a cost of +€775; and 7) a Stove and Hearth in the amount of +€1,300.

Finally (06) Preliminaries include the time related costs for the construction of the units but not incorporated in the finished dwelling e.g. the cost of site supervision, cost of scaffold, cost of insurances, cost of plant etc. It is seen that there are additional costs for the construction of the A3 dwelling due to an increased length in the programme critical path of five working days (which arise in the mechanical and electrical first fix and the construction of the chimney stack in the A3 unit not required of the PH). These cost differences can be summarised as follows: add cost of site overhead and preliminaries associated with additional 5 day programme (+€2750), add Planning Contributions discount not available to A3 unit +€225, omit cost of PHPP Fee -€540, omit cost of blower door test -€170, therefore additional cost to construct the A3 unit €2,265 excl VAT.

The total cost of constructing an nZEB dwelling (i.e. achieving a BER of A1 by building to the passive house standard) therefore amounts to a reduction of €131 excl VAT when compared to an A3 rated dwelling at current building regulations.

Conclusion

This analysis has shown that the construction cost differential of ensuring compliance with the nZEB standard (and achieving a BER of A1) compared with constructing to the minimum building regulations (i.e. achieving a BER of A3), are €131 for the case study dwelling (which was constructed to the passive house standard), with the nZEB dwelling being less expensive.

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